made. In the dry sections cotton, while holding its own remarkably well, was beginning to suffer for moisture; picking began in some of the southern counties about the 15th, and by the close of the month a number of bales had been ginned and marketed.—*N. R. Taylor.*

Utah.—The mean temperature was 75.4°, or 2.7° above normal; the highest was 115°, at Hite on the 10th, and the lowest, 27°, at Soldier Summit on the 4th. The average precipitation was 0.41, or 0.19 below normal; the greatest monthly amount, 1.76, occurred at Frisco, while none fell at Corinne and Kelton.

One of the warmest, if not the warmest, months since the settlement of the State.—*L. H. Murdoch.*

Virginia.—The mean temperature was 78.6°, or 1.3° above normal; the highest was 106°, at Stephens City on the 1st, and the lowest, 47°, at Burkes Garden on the 9th. The average precipitation was 4.94, or 0.42 above normal; the greatest monthly amount, 9.82, occurred at Alexandria, and the least, 2.44, at Callaville.

The month, as a whole, was quite favorable for crop growth and work. Extremely high temperatures prevailed during the first and last days of the month, but no crop damage resulted. There were also a number of heavy, washing rains and some freshet water in small streams. These were productive of some harm to lowland corn and tobacco, but not sufficient to materially affect the general situation.—*Edward A. Evans.*

Washington.—The mean temperature was 62.8°, or 2.5° below normal; the highest was 106°, at Pasco on the 30th, and the lowest, 30°, at Snoqualmie Falls on the 12th. The average precipitation was 0.57, or 0.07 below normal; the greatest monthly amount, 2.48, occurred at Ilwaco, while none fell at Ellensburg, Lakeside, and Pasco.

Although rather cool for corn and several kinds of vegetables, the month was the best possible for the heading out and filling of spring wheat. It was also very favorable for haying, and ideal for fall wheat harvesting.—*G. N. Salisbury.*

West Virginia.—The mean temperature was 77.4°, or 3.7° above normal; the highest was 104°, at Magnolia and New Martinsville on the 1st, and the lowest, 47°, at Philippi on the 9th. The average precipitation was 3.16, or 1.63 below normal; the greatest monthly amount, 6.21, occurred at Josiah, and the least, 0.69, at Parkersburg.

Fine harvest weather during the month; wheat cutting completed by the fourth week, and wheat mostly in stack and thrashing begun, but yield not meeting expectations, there not being more than half to two-thirds crop. Clover and rye cutting mostly over by second week, with fair yields. During the third week grass and oat cutting in general progress, and by the last of the month, these crops had been mostly saved in fine condition, with a good crop of hay and a fair yield of oats. Crops of all kinds continued to improve until the fourth week, when the intense heat and drought began to have an injurious effect, especially on corn, gardens, and potatoes. Apples continued to fall, and the prospect was for not more than half a crop; peaches plentiful, but small and of inferior quality.—*E. C. Vose.*

Wisconsin.—The mean temperature was 75.3°, or 5.8° above normal; the highest was 111°, at Brodhead on the 21st, and the lowest, 33°, at City Point on the 7th. The average precipitation was 4.29, or 2.23 above normal; the greatest monthly amount, 9.17, occurred at Florence, and the least, 0.86, at Racine.

The month was characterized by a severe and protracted drought over the southern section of the State, which, together with the excessive heat, caused much damage to corn, tobacco, and other crops. In the central and northern portions the rainfall was ample, and in some localities excessive. In the central and northern sections a large hay crop was secured in excellent condition, and other crops are satisfactory.—*W. M. Wilson.*

Wyoming.—The mean temperature was 71.3°, or 4.4° above normal; the highest was 110°, at Fort Bitter Creek on the 14th and 16th, and the lowest, 23°, at Daniel on the 5th. The average precipitation was 0.70, or 0.39 below normal; the greatest monthly amount, 2.87, occurred at Casper, while none fell at Embar and Hyattville, and but a trace at Lander and Fort Washakie.—*W. S. Palmer.*

SPECIAL CONTRIBUTIONS.

THE THUNDERSTORM; A NEW EXPLANATION OF ONE OF ITS PHENOMENA.

By BYRON MCFARLAND, A. B., dated Monroe City, Mo., June 17, 1901.

The daily weather maps issued by the United States Weather Bureau show that areas of high pressure, and areas of low pressure—or highs and lows—are continually passing across the continent in a more or less easterly direction. Thunderstorms occur usually in these lows and are therefore called secondary storms, being small, local storms in a large, or general, storm area. These storms furnish the chief supply of rain during the summer months. There can be little doubt but that thunderstorms are composed of rising air and descending air; the air currents blow both *to* and *from* the thunderstorm—both *up* and *down* in it. A peculiar feature of the thunderstorm is the coolness of the air within it. At the storm's arrival the temperature may drop from 10° to 30° F., or even more.

Some of the facts known about thunderstorms are as follows: (*a*) from some distance in front the air blows toward the storm, turns upward as it approaches it, and finally enters the main cloud. (*b*) On the ground below the margin of the cloud the air blows from the cloud; this forms the "squall" or strong cool wind that usually precedes the main storm proper. (*c*) In the center of the storm, the air is more nearly calm than at the border—especially its front border. (*d*) The air pressure is greater in the center of the storm than just in front of the margin of the cloud, i. e., the barometer rises slightly, and generally suddenly, during the passage of the cloud. (*e*) The air in the "squall" is considerably cooler than the surrounding air.

To account for these phenomena of pressure and of air currents (*a-e*) three explanations have been offered: (1) The rain drops falling through the air, push it down and out, thus producing the rise of the barometer and the "squall" below. (2) The warm moist air rising into a region of decreased air pressure, becomes cloud and expands, and in thus pushing aside the surrounding upper air it presses downward with more than its weight, causing at once the slight rise in the barometer at the ground and the outrushing squall. The ascending air produces therefore a sort of recoil comparable to the "kick" of a gun, and this recoil is what "kicks" out the squall below. (3) The rising air above overflows into the neighboring air, and this additional weight produces the increased pressure and the squall below.

(1) The first of these explanations has undoubtedly some foundation in fact, for falling bodies will produce descending currents and lateral winds below. But the fact that the intensity of the squall is not always proportional to the intensity of the rainfall shows that the theory is only a partial explanation of the phenomena in question. (2) The second-named theory is even less tenable. That cloudy air in ascending cools more slowly, and hence expands more rapidly than dry air, is quite true; but this expanding air can not "kick" a constant squall out of the bottom. I will admit that should a large mass of warm, cloudy air be in some way carried up to the center of the convectional column and there suddenly turned loose, it would expand and increase temporarily the pressure down at the ground. But the thunderstorm is a continuous process of some duration. The following statements appear to me as being in this connection unquestionably true, viz, (1) the pressure at the ground could not be increased without the pressure above being also and even first increased; (2) the increased pressure at the ground could not be maintained (as it in fact is) unless the increased pressure above be maintained; and (3) if the increased pressure above be maintained, convection would cease, and the thunderstorm would be brought at once to an end.

In my judgment, the only condition under which air can continue to rise for hours into the upper part of the storm is the presence there, not of increased, but of relatively decreased air pressure. The idea that the rising and expanding air above can maintain a constant downward recoil or "kick" sufficient to produce the squall, and at the same time not interfere with the incoming currents above, seems hard to understand. For it could not "kick" at all unless its pressure be increased; and if its pressure be increased, it would "kick" in all directions, and would "kick" back the incoming currents and prevent them from entering the storm area at all. The surrounding air could not enter until the high pressure had given way to lower pressure; but when this takes place, the high pressure on the ground would also give way to lower pressure, and the squall would cease. But, in fact, both the inflowing currents above and the outrushing squall below blow with comparative uniformity, thus showing that there are some sort of constant barometric conditions established, which insure a low pressure above and a relatively high pressure below.

(3) The "convectional overturn" theory has the same weakness that the "kick" theory has, because (*a*) the upper air could not "overflow" until its pressure be greater than that of the surrounding air; (*b*) if the overflowing air above has relatively greater pressure, it will produce greater pressure below also, unless the column is abnormally warm or light, and we should have the anomaly of air rising into relatively higher pressure and settling in lower pressure.

The explanation which I wish to suggest is based on the well-known coolness of the air in the squall. Under uniform pressure, the density of the air decreases 1/491 of that at 32° F. for every degree Fahrenheit above the freezing point of water.

We will suppose the distance from the thundercloud to the ground to be 1,300 feet (it may be more), and suppose, also, that the air between the cloud and ground is, on an average, 15° F. cooler than the surrounding air (it is often considerably more). It may easily be found that the difference in weight of these two columns of air (each 1,300 feet high) would be about 0.04 inch of mercury, that is to say, placed side by side, the cool column would support 0.04 inch more mercury than the warm column would. Evidently, if the air be much cooler (say 35° F.), and if the height of the cool column be several thousand feet, the difference in weight would be much more marked. The presence of this cool column of air, then, extending from the cloud to the ground, will account for the higher air pressure below. But not only this, it will account, also, for the permanent low above. If a series of isobars be drawn in a vertical plane section through the thunderstorm, the isobaric surfaces will crowd together in the cool column and be farther apart in the surrounding region of warm air. The higher pressure below will suffice to produce the squall, and the lower pressure above will permit convection to go on undisturbed.

The rise in barometer during the passage of a thunderstorm is usually very slight. I have often noted, in well defined storms, a rise of not more than 0.03 inch. In very violent storms, however, the rise may be considerably more, as much as 0.15 or even 0.25 of an inch. But it is a notable fact that in these violent storms, the drop in temperature is very marked. This is just what we should expect if the "cold air" theory is true. I have yet to hear of a thunderstorm accompanied by a typical squall in which the air of the squall was warmer than the surrounding air.

The "cool air" theory will undoubtedly suffice, provided only the cool air column is present. And as indications that the column of cool air does exist, we mention the following: (1) The internal air of the squall is considerably cooler on the ground. (2) The fact that the so-called wind cloud is usually much lower than the other convectional clouds which are fed from air of like temperature and humidity, shows that the rising air meets with relatively cooler air below the margin of the cloud.

There are, of course, several things to be remembered in applying this "cool air" theory. Confessedly there are still a good many "unknowns" in the thunderstorm; but the following will evidently modify and determine the violence of the squall. (1) The average difference of temperature between the cool column and the surrounding air. (2) The height of the cool column. (3) The diameter of the cool column. (4) The progressive motion of the storm itself. No one of these four will alone determine the violence of the squall. In general, the intensity of the squall will vary directly with the relative coolness of the column, its height, and its diameter. But these factors may vary considerably among themselves, and there can be no narrow, cast-iron rules laid down. We should expect to find the squall strongest when these factors combine and weakest when they are weak.

The progressive motion of the storm will affect the squall somewhat, making it apparently stronger in front than behind.

As to the origin of the cold air of the squall there is some diversity of opinion. By some it is thought that the coolness of the air is due to cold rain falling through it. In many cases this seems a sufficient explanation. Thunderclouds probably often extend above the snow line. The melting of this snow, the warming of the cold water in its descent, and the resulting evaporation of some of it, might well keep the air through which it falls several degrees cooler than the outside air. The amount of air that rises into the thunder cloud is apparently several times greater than that which blows out from it below. The falling snow and rain cool a comparatively small amount of air beneath the clouds.

Cool squalls in the absence of rain are thought to be caused by the settling of overlying masses of air that are intrinsically and abnormally cold. This is entirely probable. It is generally supposed that thunderstorms, especially those accompanied by tornadoes, are overlaid by layers of cold air. But it is more probable, I think, that many of the wind clouds, unaccompanied by rain, are the last remnants of former thunderstorms, or are the products of actions that were too feeble to produce a thunderstorm.

It seems pretty certain that the circulation of air in an active or "typical" thunderstorm is as about as follows: The air from around rises toward the cloud; the inner layer of this ascending air meeting with the falling snow or rain is cooled, and also pushed down by the rain drops; both cooling and pushing cause it to be turned downward. And as it is more and more cooled (i. e., relatively), and continually beaten down by the falling rain, it settles more and more rapidly, and on reaching the ground becomes the cool outrushing squall. The presence and the appearance of the so-called "wind cloud" that generally just precedes the rain cloud, seems to indicate this. It is a long light-colored fleecy cloud that suggests a huge roll of wool. A cloud formed at the level where the rising air turns to descend would have an appearance like this.

A METEOROLOGICAL BALLOON ASCENSION AT STRASBURG, GERMANY.

By A. LAWRENCE ROTCH, Direct r of the Blue Hill Observatory, dated Aug. 7, 1901.

Through the courtesy of Professor Hergesell, the President of the International Aeronautical Committee, the writer (who is the American member of the Committee) participated in the eighteenth series of balloon ascents on July 4, 1901, when balloons were dispatched from Paris, Berlin, Strasburg, Munich, Vienna, and St. Petersburg. The manned ascension from Strasburg was made by Professor Hergesell and the writer in the new cotton balloon "Girbaden," of 1,300 cubic meters, belonging to the Aeronautical Society of the upper Rhine. On this occasion this balloon was filled with coal gas and had a lift at starting represented by sixteen sacks of ballast weighing together about 300 kilograms.